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Abstract

URANIUM/PLUTONIUM CERAMIC FUELS

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Uranium/plutonium ceramic fuel fabrication and irradiation studies for both thermal and fast reactor applications have been accelerated rapidly in recent years. The quantity of such fuel irradiated in the United States during 1963 was twice that tested in 1962 and the amount is expected to double again in 1964.

It has been demonstrated that plutonium-bearing fuel elements can be fabricated on a pilot plant scale, safely and at little additional cost over that of fabricating uranium elements. For example, the cost of fabricating UO_2/1 wt% PuO_2 fuel elements is less than 10% greater than for UO_2. For reactors in which plutonium has unique advantages, therefore, it no longer appears logical to continue arguments that the plutonium must always be burned in situ or stored indefinitely.

Fabrication technology is being developed at several sites according to their specific interests. Processes applied to UO_2/PuO_2 include co-precipitation, mechanical blending, pressing and sintering, swaging, vibrational compaction, and high-energy impaction. The last mentioned technique provides the latest improved method for forming the most dense mixed oxides, other compounds and cermets of known composition. Sintering as well as fusion and casting of UC/PuC is being developed.

Demonstration-scale production and testing of mixed-oxide fuel elements has highlighted problems associated with use of conventional industrial equipment. In some instances impurities introduced into the fuel processing stream by such equipment caused fuel element failures. Fuel holdup, loss, and criticality control measures are now well developed.

Increased attention is being directed to adapting the newer fabrication techniques to partially decontaminated, irradiated uranium/plutonium fuels and to developing novel fuel elements such as those that can be repeatedly re-enriched, or rejuvenated and reirradiated without full chemical reprocessing. Beyond this, concepts for extending the useful life of a fuel element, such as by alternating it between thermal and fast reactors, are under investigation. Preliminary results are promising.

Although studies of compounds other than oxides have been fruitful, data from fabrication, irradiation, and fundamental studies of oxides have been developed more rapidly. For example, tons of mixed plutonium/uranium oxide were irradiated during the past year, compared to tens of kilograms of mixed carbides and a few kilograms, at most, of other compounds.

The effects of plutonium additions to the properties of uranium compounds are partly known, and uranium/plutonium oxides generally appear capable of adequate performance in thermal or fast reactor power stations now being designed. Plutonium oxide has been irradiated to exposures of more than 66×10^{20} fissions/cm^3 (200 000 MWd/ton) at heat generation rates exceeding those anticipated in fast reactors. UO_2/20 wt% PuO_2 has been successfully irradiated to 33×10^{20} fissions/cm^3 (100 000 MWd/ton) and important information on fission-gas release and fuel relocation obtained. Transient tests to several hundred times normal operating powers were conducted. Temperature-modified reactivity effects, fuel segregation, fission-product movement and melt-down effects need further study.

Irradiation tests of mixed uranium/plutonium carbide have been conducted successfully by several sites in the United States, some to more than 13×10^{20} fissions/cm^3 (43,600 MWd/ton). Other current tests have goal exposures exceeding 27×10^{20} fissions/cm^3 (91 000 Mwd/ton). These fuel experiments in support of sodium-cooled reactor technology are being supplemented by studies of physical and thermal properties, and of compatibilities with cladding materials.